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Development of closed extruding fine blanking technology

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Abstract

The closed-extruding fine blanking was developed to form thick plate and low plasticity materials. In this paper, the principle and process of the closed-extruding fine blanking were elaborated. The material flow and the influence of the process parameters on the forming quality were analyzed. At the same time, by means of metallographic observation and analysis of microhardness as well as surface residual stress, the characteristics of the material in the closed-extruding fine-blanking process were investigated.

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Keywords: Fine blanking; Extruding; Forming.

1. Introduction

Fine blanking is a specialized precision stamping, metal forming process (Tu Guang-qi, 1990). Most fine blanking operations incorporate a V-ring. Before the punch contacts the part, the ring impales the metal surrounds the perimeter of the part, and traps the metal form moving outward while pushing it inward toward the punch. This reduces rollover at the cut edge. Therefore, precise finished components can be produced with inner and outer forms that are cleanly sheared over the total material thickness, while achieving superior overall flatness. However, this technology is only suitable for the thin plate or the high plasticity materials. So it is necessary to develop a new fine-blanking process for the thick plate and low plasticity materials (Deng Ming et al., 2010).

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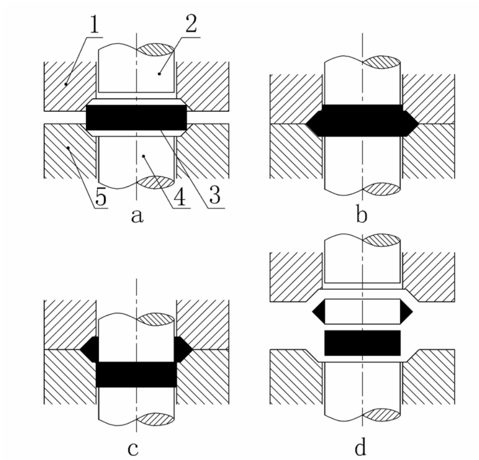
With the increase of triaxial compression stress, the blank is gradually separated along the expected contour, which is helpful to obtain high precision profile (Deng Ming, 2009). Based on previous research of our group, a new type of fine blanking technology is developed to form thick plate and low plasticity materials, that is the closed-extruding fine blanking. In this paper, the principle and process of this new technology are elaborated. The material flow and the influence of the process parameters on the forming quality are analyzed. At the same time, by means of metallographic observation and analysis of microhardness as well as surface residual stress, the characteristics of the material in the closed-extruding fine-blanking process are investigated.

2. Principle and process of the closed-extruding fine blanking technology

The closed-extruding fine blanking is a new forming technique that combines fine blanking and cold extrusion. It is well known that triaxial compression stress state is beneficial to prevent cracks from generating and propagating (Deng Ming et al., 2011). This is the principle of the closed-extruding fine-blanking technique. By means of pre-extrusion of the material in closed cavity, triaxial compression stress state in the core deformation zone is obtained.

The forming process of the closed-extruding fine blanking is shown in Fig. 1. Firstly, as shown in Fig. 1a, lock the punch and vice die in a specific location and move them down together. Secondly, when the vice die contacts the main die, stop moving the punch, which is shown in Fig. 1b. Thirdly, as shown in Fig. 1c, keep the stress and position of vice die constantly and move the punch down so that it can push the billet into the die continually while counterpunch continues exerting forces to complete the process. Finally, open the mold and then push the counterpunch to get the part, which is shown in Fig. 1d.



1-vice die, 2- punch, 3- work-piece,
4-counter punch, 5-main die

Fig. 1. Basic process of closed-extruding fine blanking.

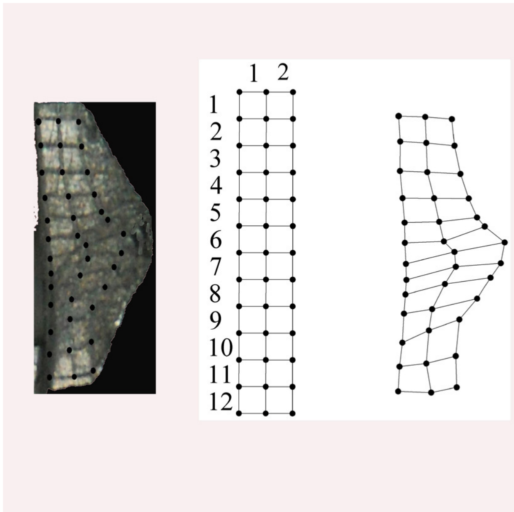


Fig. 2. Flow pattern of the closed-extruding fine-blanking process.

3. The material flow in the process of the closed-extruding fine blanking

The material flow in the process of the closed-extruding fine blanking is studied based on experiments. As can be seen from Fig. 2, when the vice die moves down, the material in the sharp corner of the blank is yielded firstly. The material below the sharp corner flows radially outward while the material beside the sharp corner flows along the circumferential direction. Furthermore, the metal flow in the shear zone is similar to that of the strong pressure side of the existing fine blanking, that is to say deformable material is bound in a limited area while the surrounding material has no significant deformation.

In order to analyse the metal flow in the deformation zone of the closed-extruding fine blanking process in-depth, the workpiece through metal grid experiment is cut along the axis and eroded with 15% sodium hydroxide solution about 20 s. The metal flow line of the shear zone is shown in Fig. 3. It is clear that the shear zone is near to the connection between the cutting edge of main die and that of the vice die, which is also similar to that of the strong pressure side of the fine blanking. Furthermore, in the connection to the region 2 mm width as the center of the strip, deformation is violent and the flow line is significant. At the same time, in this area, a large number of flow lines are squeezed together and can not distinguish. The metal flow distribution is similar to that of extrusion process.

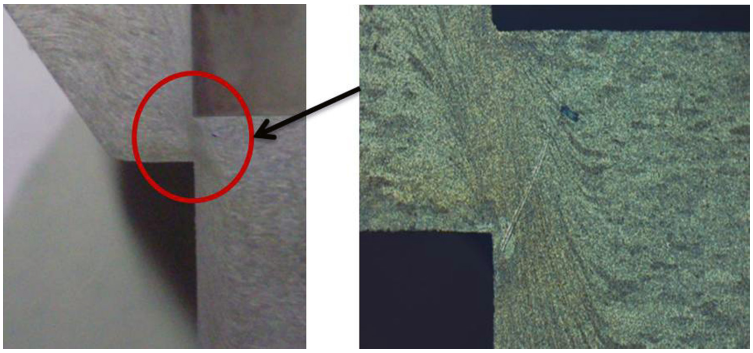


Fig. 3. Metal flow line of the shear zone.

4. Influence of the process parameters on the forming quality

4.1. Ratio between the mold structure parameters and shiny belt

Fig. 4(a) shows the influence of the punch-die clearance on the proportion of light band. It is clear that the proportion of light band is inversely proportional to the punch-die clearance.

Fig. 4(b) shows the relationship between the quality of shearing surface and different corner radius. It can be seen that the quality of the shearing surface is proportional to the corner radius of the main die. However, the radius should have a proper range. Once the workpiece is stuck in the mold cavity, it will be difficult to remove.

Fig. 4(c) shows the influence of the pressure edge length of die on the quality of the shearing surface. It can be seen that the quality of the shearing surface will reach a certain value when increasing the vice die edge length. But there is no clear relationship between them.

Fig. 4(d) shows the influence of the vice die cavity taper on the forming quality. It is obvious that the big cavity taper is helpful to obtain the good forming quality. However, when the cavity taper is over 80 degrees, the quality of the shearing surface is worse than before.

Fig. 4(e) shows the relationship between the proportion of light band as well as the preset height of punch and vice die. But there is no clear relationship between them.

Through orthogonal test, the influence of various process parameters on the proportion of light band is in the descending order: the clearance of punch and main die, the main die corner radius, the vice die edge length, the punch and vice-die preset height, that is to say the influence of the clearance is far greater than that of the other parameters.

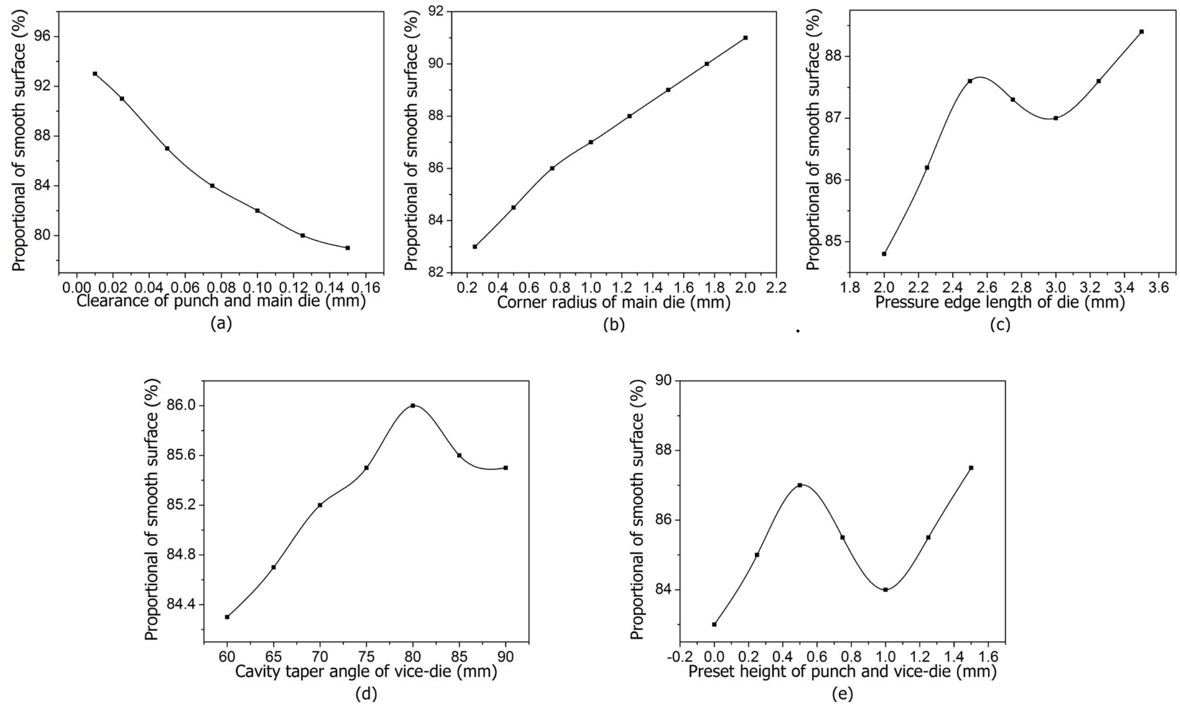


Fig. 4. Proportional relationship between technical parameters and smooth surface.

4.2. Proportion of counterforce and smooth surface

Fig. 5 gives the proportion of the smooth surface in different clearance and different counterforce. It can be seen that the quality of the shearing surface is proportional to the counterforce. Moreover, to the same proportion of brightness, the smaller the clearance is, the lower the counterforce is (Deng Ming et al., 2011).

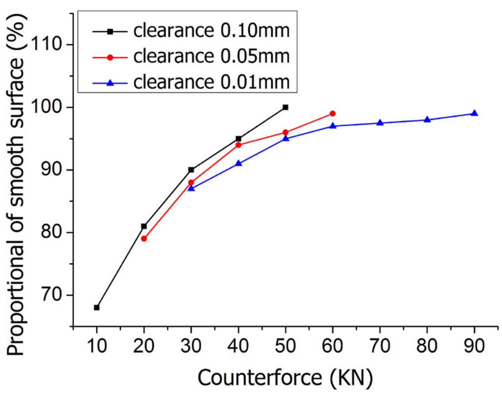


Fig. 5. Proportion of the smooth surface in different clearance and different counterforce.

5. Forming surface properties and microscopic characteristics

5.1. Changes in grain shape

As can be seen from Fig. 6(a), initial equiaxed grains in the undeformed region are uniform and arranged no obvious direction. But in the large deformation region, large amount of grains are elongated along the deformation extrusion direction and showed more regular linear arrangement, which is shown in Fig. 6(b). This means that in the deformation process of the closed-extruding fine-blanking, the core material deformation is very small while the external surface of the material is deformed largely. The effect of extrusion is beneficial to prevent cracks from generating.

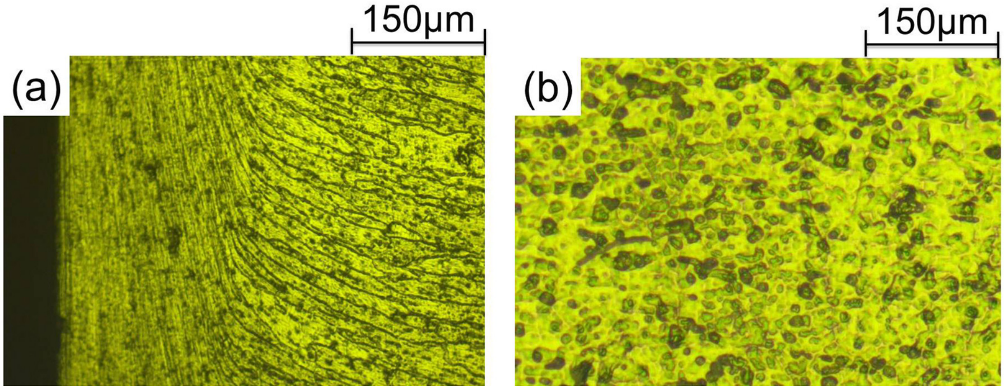


Fig. 6. Cross section metallograph. (a)metallographic flow line, (b)metallographic structure.

5.2. Hardness of the deformation zone

Fig. 7 shows the distribution of hardness of radial sheared surface. The hardness of central parts is high while the burr side and corner side are low. At the final stage of the process, due to the effect of internal crack, the hardening effect of the sheared surface becomes weak, and the hardness of the burr side is low .As can be seen from Fig. 7, the distribution of hardness of the sheared surface is shown as a “C”.

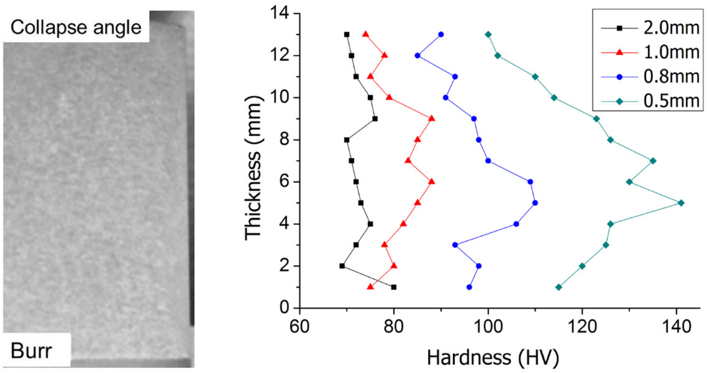


Fig. 7. Distribution of hardness of the sheared surface.

5.3. The distribution of the surface residual stress

Fig. 8 shows the residual stress distribution of processing surface in the vertical direction from the collapse side, and the residual stress is compression stress. The residual stress value of -112 MPa by distance 2 mm from collapse side increased to -137 MPa by distance 10 mm from collapse side. This is because in the closed extruding fine blanking process, materials of collapse side firstly enter into the main die and plastic deformation happens. As the process proceeding, more surface materials are squeezed and strong plastic deformation happens in the direction of main die movement. This suggests that larger distance from the collapse side can directly increase the accumulation of material. As a result, the surface compression stress will increase gradually when deformation increases.

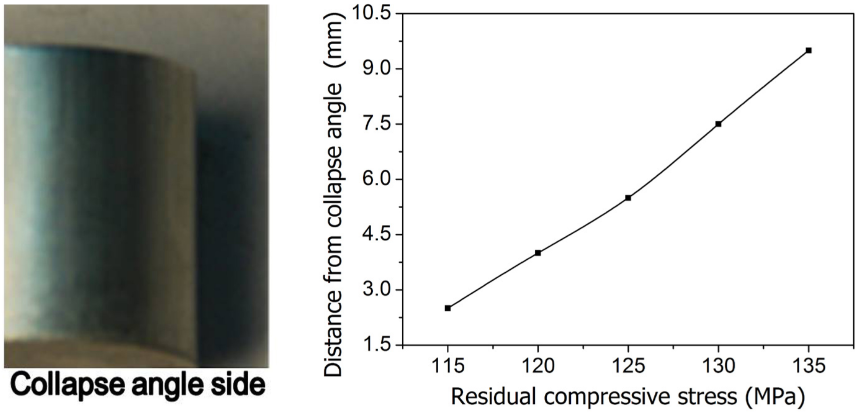


Fig. 8. Distribution of the surface residual stress

6. Conclusions

(1) The influence of various process parameters on the proportion of light band is in the descending order: the clearance of punch and main die, the main die corner radius, the vice die edge length, the punch and vice-die preset height, that is to say the influence of the clearance is far greater than that of the other parameters.
(2) With the fine-blanking process proceeding, the quality of the shearing surface increases when the counterforce increases.
(3) Within a certain range, the farther distance from the collapse side is, the more materials accumulation is. With the increase of material deformation, the parts surface compression stress increases gradually.

Acknowledgements

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